R E P O R T R E S U M E S

ED 002 779 24

PERCEPTION OF SYMBOLS IN SKILL LEARNING BY MENTALLY RETARDED, GIFTED, AND NORMAL CHILDREN.

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REPORT NUMBER CRP-151 PUB DATE NOV 57
EDRS PRICE MF-$0.18 HC-$2.84 71P.

DESCRIPTORS- MENTAL RETARDATION, *RETARDED CHILDREN, LEARNING, *INTELLIGENCE, SPECIAL CLASSES, PUBLIC SCHOOLS, COMPARATIVE ANALYSIS, *SKILL DEVELOPMENT, *GIFTED, *SYMBOLIC LANGUAGE, PERCEPTION, MADISON, WISCONSIN

HOW CHILDREN OF DIFFERENT MENTAL ABILITIES PERCEIVE LEARNING TASKS WAS STUDIED. THREE GROUPS OF 10 CHILDREN EACH (5 BOYS AND 5 GIRLS) WERE THE SUBJECTS OF THIS PROJECT. THE CHILDREN WERE SELECTED SO THAT THE GROUPS WERE HIGHLY SIMILAR IN CHRONOLOGICAL AGE, BUT DIFFERED DISTINCTLY IN IQ. ONE GROUP WAS COMPOSED OF GIFTED CHILDREN FROM A GIVEN SCHOOL OF 810 CHILDREN, ONE GROUP WAS FROM MADISON PUBLIC SCHOOLS, AND ONE GROUP WAS FROM SPECIAL CLASSES FOR THE MENTALLY RETARDED. EACH CHILD WAS ASKED TO PERFORM CERTAIN TASKS INVOLVING HIS PERCEPTION AND REPRODUCTION OF SYMBOLS, AND HIS RESPONSES WERE NOTED BY OBSERVATION AND POLYGRAPHS. THESE TASKS REPRESENTED THE SCHOOL LEARNING TASKS OF HANDWRITING, SPELLING, ARITHMETIC, AND READING. THE DATA RECORDED ON THE PUPILS WERE ANALYZED TO TEST THE HYPOTHESIS THAT RETARDED CHILDREN PERCEIVE AND ACT ON SYMBOLS IN ESSENTIALLY THE SAME MANNER AS DO GIFTED AND NORMAL CHILDREN. HIGH AND SIGNIFICANT DEGREES OF CONSISTENCY WERE DISCOVERED AMONG THE THREE GROUPS OF CHILDREN WITH RESPECT TO THEIR RESPONSES TO THE VARIOUS EXERCISES USED. SIGNIFICANT DIFFERENCES WERE NOTED, HOWEVER, AMONG SEVERAL OF THE GROUP MEAN SCORES. THIS EXPLORATORY STUDY PROVIDED THE BASIS FOR THE DEVELOPMENT OF MANY IMPORTANT CHANGES AND IMPROVEMENTS IN TESTING PROCEDURES, INSTRUMENTATION, AND SAMPLE DEFINITION. (GC)

ED 002779

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University of Wisconsin

Final Report
November 1957

Project SAE 6436 (November 28, 1956)

Perception of Symbols in Skill Learning by Mentally Retarded, Gifted and Normal Children

For the Committee
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Introductory Note

This final report supplements and completes earlier progress reports dated March 11, 1957 and July 30, 1957, on an exploratory study of thirty children of approximately the same chronological age and school background but of three significantly different mental age groups. This project, SAE 6436, was authorized for a six month period beginning in January 1957; it has since been authorized as a four year project.

This report which completes project SAE 6436 consists of two major sections. Section I presents the basic data of the exploratory study and its analysis. Section II is a summary of the major findings and the implications of these findings and related experience for future research on this problem.

ACKNOWLEDGMENT

"The research reported herein was performed pursuant to a contract with the United States Office of Education, Department of Health, Education, and Welfare."

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Perception of Symbols in Skill Learning by Mentally Retarded, Gifted, and Normal Children (Project SAE 6436)

Nature and Role of Final Report

This report is written as a supplement to the two previous progress reports and is, therefore, not intended to serve as a complete documentation of the total range of activities of this project. The progress report of July 30, 1957, presents the material on the nature of the problem studied, the population, basic experimental apparatus and records with pictures, sequence of testing and procedures, and a preliminary statement of tentative findings.

This concluding report devotes itself exclusively to the presentation of the basic data of the study and its analysis. No effort is made to review the previous discussions on problem, population, and methodology. Naturally, some of the conclusions of the study and their implications for future research will have bearing on these topics and will be so indicated in the final section of this report.

Section I

Analysis of Data

1. Screening Procedures for Vision and Motor Coordination

As each child was brought into the laboratory for study, screening tests for both vision and motor coordination were administered as a preface to other testing. This served as a way of introducing the child to the laboratory situation and to acclimate them to testing procedures. Previously, the school records had been checked for extreme visual and auditory difficulties and for physical handicaps which would have prevented the child from engaging in the experimental activities. These screening tests, however, serve as additional checks on these factors.

Vision

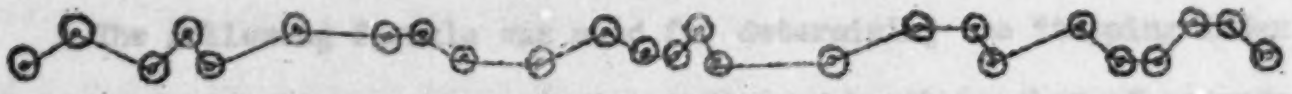
No child of the three groups of students included in this study failed the five specific tests of vision selected from the Keystone Visual Survey Tests. The following tests were used: Test 1 (Simultaneous Vision at far point), Test 3 (Lateral imbalance at far point), Test 4 (Vision at far point), Test 5 (Right eye, usable vision at far point) and Test 6 (Left eye, usable vision at far point).

All tests were presented to the child at far point and represented a more difficult sight problem than did the demands made by the reading materials used in this perception study.

Motor Coordination

The motor coordination test used was the one developed by Professor G. Lawrence Rarick and Theodore Harris of the Research Committee. Targets were devised so as to maximize the eye, hand, arm coordination involved in accurate rapid hitting of the individual target with a stylus. Electrical contacts made by the hits were recorded by a counter. The diagram of the target pattern used in this study is given in Figure 1.

Figure 1
Target Pattern of Motor Coordination Test



Instruction

Each subject was given the following instructions.

"We would like you to show us how (fast) rapidly and accurately you can tap with this pencil. You will start here (show beginning point) and poke each dot as fast as you can following along on the white line."

"Watch how I hold the stylus (pencil) and use it to jab the dots. (Show child and explain the clicks and counter). You are to make only one jab at each dot. If you miss go on to the next. Ready! go!"

The experimenter times each of the three trials to the nearest ½ second. There are twenty-five dots and the experimenter has to count the number of times the subject pokes more than once at a given dot. This number is to be added to the number of misses. In spite of the instructions to the contrary, many children are disposed to poke again at a target after a miss before going on to the next dot.

This aspect of the coordination test is inadequate. Our equipment needs to count the misses as well as the hits. Another source of error was the tendency of the counter to count more than one hit when the point of the stylus was drawn across a given contact point. Subsequent use of this equipment will need these improvements in order to increase the confidence one has in these coordination scores.

Scoring and Tabulation of Data

Three scores were obtained for each subject. The number of hits, number of misses, and the time in seconds. One preliminary trial was given to acquaint the subject with the procedure and to "warm up" on the task. Two additional trials were obtained and the scores of these trials are used in the computations.

The following formula was used for determining the "tapping index." Number of hits minus number of misses divided by the number of seconds. It is argued that both hits and misses need to be considered in examining motor coordination (the act of relating eye-hand coordination systems to the efficient accomplishment of a particular purpose). The most accurate score was considered as 25 hits in the 25 attempts. The most efficient score would be the ratio of this degree of accuracy to the fewest number of

seconds. Thus the numerical size of the index is a function of both accuracy and efficiency (speed). The best score is the largest positive index obtained. The poorest score has to be considered from two points of view. First, when hits minus misses approaches 0 and when the number of seconds (divisor) becomes large, then the index approaches 0. This condition tends to pertain when the hits and misses approximate a chance relationship and the time between individual "pokes" becomes great. This is one kind of "poor coordination." A second kind of poor score is when the number of misses approaches 25 but the number of seconds taken in poking approaches 0. In this case the index is negative and may become very large. These two conditions represent the two extreme limits within which poor coordination scores may range.

Table 1 presents the results of the tapping test for the total experimental group. Columns 1 and 2 present the original indices. Columns 3 and 4 are these indices with a constant 71 added to each score to make them positive.

See Table 1 on page 5

The product-moment correlation of the two trials of the whole group is .90. The t test of significance is .6517 or significant at the 55% level. This indicates that the relative performance of the total group on the tapping test for the two trials is very similar. We can hold to the null hypothesis at the 55% level of confidence. Considering the group as a whole, one warm-up trial is apparently sufficient to permit all individuals to reach their consistent level of tapping performance.

Differences in Performance of Three Groups

The second hypothesis investigated in examining the results of the tapping test was "The performance of the three groups of children (bright, normal, dull) on the tapping test is the same."

See Tables 2 and 3 on page 6

Table 1

Results of Tapping Test for Total Group*

Subjects	1	2	3	4
Code No.	Trial I	Trial II	Trial I & II	Trial II & II
23.I.F.a.	1.06	.31	177	102
22.I.F.a.	1.11	1.59	182	230
16.I.F.a.	1.00	1.79	171	250
27.I.F.a.	1.20	.88	191	159
30.I.F.a.	.43	.90	118	161
21.I.M.a.	1.59	1.33	230	204
18.III.M.c.	.81	.69	152	140
24.I.M.a.	1.13	1.47	184	218
25.I.M.a.	.58	1.07	129	178
28.I.M.a.	1.11	.30	182	101
29.I.M.a.	1.54	1.62	225	233
6.II.F.a.	1.40	1.47	211	218
9.II.F.a.	1.16	.83	187	154
12.II.F.A.	1.13	1.29	184	200
13.II.F.a.	1.00	.93	171	164
19.II.F.a.	.80	.50	151	121
1.II.M.a.	1.00	1.04	171	175
4.II.M.a.	1.54	1.02	225	173
11.II.M.a.	1.52	1.27	223	198
15.II.M.a.	1.20	.82	191	153
26.II.M.a.	-.31	-.61	40	10
2.III.M.c.	1.39	.90	210	161
3.III.F.b.	.78	.72	149	143
5.III.F.b.	.92	.82	163	153
7.III.F.c.	1.00	1.00	171	171
8.III.F.b.	.60	.70	131	141
10.III.M.b.	.68	.65	139	136
17.III.F.c.	.31	.36	102	107
20.III.M.b.	.52	.49	123	120
14.III.M.b.	.62	.67	133	138
$r^{I,II}$ = .90		Mean =	167	160
"t" = .6517 - 55%		σ =	32.46	49.08

*Tapping score determined by: Score = $\frac{\text{Hits - Misses}}{\text{Time in seconds}}$

Table 2

Comparison of Index of Hits for Groups I, II, III on Trials A and B

Group I				Group II				Group III			
A	B	A^2	B^2	A	B	A^2	B^2	A	B	A^2	B^2
177	102	31329	10404	211	218	44521	47524	152	140	23104	19600
182	230	33124	52900	187	154	34969	23716	210	161	44100	25921
171	250	29241	62500	184	200	33856	40000	149	143	22201	20449
191	159	36481	25281	171	164	29241	26896	163	153	26569	23409
114	161	12996	25921	151	121	22801	14641	171	171	29241	29241
230	204	52900	41616	171	175	29241	30625	131	141	17161	19881
184	218	33856	47524	255	173	50625	29929	139	136	19321	18496
129	178	16641	31684	223	198	29729	39204	102	107	10404	11449
182	101	33124	10201	191	153	36481	23409	123	120	15129	14400
225	233	50625	54289	40	10	1600	100	133	138	17689	19044
4 1785	1836	330317	362320	1754	1566	313084	276044	1473	1410	224919	201890
M 178.5	183.6	33031.7	36232	175.4	156.6	31306.4	27604.4	147.3	141	22491.9	20189
6 34.2	50.2			23.3	55.5			28.2	17.5		

Table 3

Tests of Significance for

(Comparison of Groups I, II, III, on Trials A and B)

	Significant at:
$t_{I, III}^{A}$ = 2.2269	.05 level*
$t_{I,II}^{A}$ = 1.1304	.20 "
$t_{II,III}^{A}$ = 2.4300	.05 "*
$t_{I,III}^{B}$ = .7464	.05 "*
$t_{I,II}^{B}$ = .7464	.45 "
$t_{II,III}^{B}$ = .8478	.40 "
t_{II}^{AB} = .9873	.35 "
t_{I}^{AB} =	more than .50 "
t_{III}^{AB} =	" " .50 "

Table 2 presents the data related to the testing of this hypothesis. The t test of significance shown in Table 3 indicates that there is a significant difference between the performance of Group I (bright) and Group III (dull) on both trials and between Group II and Group III on the first trial and not the second. The other comparisons did not indicate that any real difference in performance of these groups existed. This exploratory study shows that for this population, Groups II and III performed differently (poorer coordination scores) on the tapping test than did the bright group. This finding has implications for the motor behavior of this group on the handwriting tests in the sense that one would expect them to write in less coordinated fashion and thus less legibly.

Table 3 shows also that each group (bright, normal, and slow) performed on trials A and B in the same consistent fashion.

2. Reproduction of Writing Stimulus in Experimental Situation

The stimulus, "the fox jumped", was presented visually to each subject using the apparatus described in the previous report. The condition for this presentation was standard for all children.

Each child was asked to observe the aperture in the wall before him, informing him that the phrase "the fox jumped" would appear for a short time and then disappear. After it disappeared, the child was instructed to write what he saw on the standard card before him. The time for reproduction was recorded for each trial and the presentations of the stimulus were continued until the child wrote the stimulus correctly three successive times. The average time of these last three trials was used to determine the referent for his "normal" writing. The criterion for "fast" writing was a speed at least 10% faster than the time for his normal sample. The time for his "best" sample was allowed to vary as dictated by the child's performance of this task.

Table 4

Time for Reproduction of Writing Stimulus by Total Group

Subjects	Average of Last Three Trials	1 Normal	2 Fast	3 Best	1-2	1-3	2-3
1	17.50	13	10	15.5	-3	2.5	5.5
2	30	21	16	20	-5	-1	4
3	14	16	10	12	-6	-4	2
4	24.80	23.10	14.60	21.60	-8.50	-1.50	7
5	20.50	22	12	25	-10	3	13
6	18.10	18.20	9.50	22.60	-8.70	4.40	13.10
7	17	12	7	12	-5	0	5
8	23.25	55	19	27	-36	-28	8
9	16.10	28	11	22	-17	-6	11
10	24.33	25	12	21	-13	-4	9
11	17.20	14.20	11	26.60	-3.20	-12.40	15.60
12	14	13	9.50	17	-3.50	-4	7.50
13	14	11.50	7.50	12.50	-4	1	5
14	28.33	26	17	40	-9	14	23
15	17.67	22.50	11.80	21.20	-10.70	-1.30	9.40
16	17	16	13	24.50	-3	-8.50	11.50
17	15	12	8	16	-4	4	8
18	32	26	24	27	-2	1	3
19	24.70	14	11.50	19	-2.50	5	7.50
20	31.67	30	25	37	-5	7	37
21	24	20	17.50	28	-2.50	8	10.50
22	20	15.50	10	16	-4.50	.50	6
23	11.60	11	7.50	10.50	-3.50	- .50	3
24	23	24	13	23	-11	-1	10
25	23.33	20	14	24.50	-6	4.50	10.50
26	20.67	14	11	21	-3	7	10
27	16	15	13	16.50	-2	1.50	3.50
28	10.67	13	11.50	17	-1.50	4	5.50
29	12.20	12	9.50	13	-2.50	1	3.50
30	15.50	14	11	17	-3	3	5
Σ	608.50	577.00	377.40	626.00	189.60	-0.40	239.30
M	20.28	19.23	12.58	20.86	-6.32	-.013	7.97

Results of Stimulus Presentation

Table 4 presents the data for this portion of the exploratory study. Here, the reader will find the average for the last three trials, the time for the normal, fast, and best samples and the deviation in seconds of the time of one trial when compared to every other.

When the total sample is considered, this table shows that the time for the normal sample approximated the average time for the previous three trials showing that the subjects were establishing a level of writing performance within these limits. The fast sample was, on the average, six seconds faster than the "normal" performance, four seconds beyond the time criterion. An interesting observation is that the average time for the "best" sample when you would expect the greatest writing care taken by each subject, was almost identical with the average time for the normal sample.

The implications of these general results for future studies are:

1. It is possible to establish a level of writing performance for the group as a whole.
2. The criterion and instructions for the fast sample are sufficient to insure a significantly different performance by the individuals of our total sample.
3. The time factor in the performance of "normal" and "best" samples is apparently not a differentiating variable. This is contrary to usual expectations and tends to underscore the importance of a "level of aspiration" variable in explaining "good" writing by an individual. Naturally, subsequent studies will explore this relation further.

Comparison of Times for Reproduction of Writing Stimulus for Bright, Normal, and Dull Groups

The second question to be asked of the time of reproduction data is whether our three groups of subjects performed the same.

Table 5 presents the basic data for answering this question.

See Table 5 on page 10

Table 5

Time for Reproduction of Stimulus by Groups

	Time 1	2	3	Variation 1-2	1-3	2-3
Group I	Normal	Fast	Best			
	1	2	3			
	16	13	24.5	-3	+8.5	11.5
	20	17.5	28	-2.5	8	10.5
	15.5	10	16	-4.5	.5	6
	11	7.5	10.5	-3.5	- .5	3
	24	13	23	-11	+1	10
	20	14	24.5	-6	4.5	10.5
	15	13	16.5	-2	1.5	3.5
	13	11.5	17	-1.5	4	5.5
	12	9.5	1.3	-2.5	1	3.5
	14	11	17	-3	3	5
Sum	160.5	120	190	Σ	-39.5	31.5	69.0
Ave	16.1	12	19	M	- 3.95	3.15	6.9
σ	3.67	2.60	5.36				
Group II							
	13	10	15.5	-3	2.5	5.5
	23.1	14.6	21.6	-8.5	-1.5	7
	18.2	9.5	22.6	-8.7	4.4	13.1
	28	11	22	-17	-6	11
	14.2	11	26.6	-3.2	12.4	15.6
	13	9.5	17	-3.5	4	7.5
	11.5	7.5	12.5	-4	1	5
	22.5	11.8	21.2	-10.7	-1.3	9.4
	14	11.5	19	-2.5	5	7.5
	14	11	21	-3	7	10
Sum	171.5	107.4	199	Σ	-54.1	27.5	91.6
Ave	17.2	10.7	19.9	M	- 6.4	2.75	9.16
σ	5.1	1.9	3.82				
Group III							
	21	16	20	-5	-1	4
	16	10	12	-6	-4	2
	22	12	25	-10	3	13
	12	7	12	-5	0	5
	55	19	27	-36	-28	8
	25	12	21	-13	-4	9
	26	17	40	-9	14	23
	12	8	16	-4	4	8
	26	24	27	-2	1	3
	30	25	37	-5	7	37
Sum	245	150	237	Σ	-95.0	-8.0	112.0
Ave	24.5	15.0	23.7	M	- 9.5	- .80	11.20
σ	11.69	5.98	9.05				

For Group I (Bright Group) the "t" tests are:

Sample		Level of Significance
1 = Normal	t12 = 2.8082	.02*
2 = Fast	t13 = 1.4148	.20
3 = Best	t23 = 3.7234	.01*

The difference in time between the normal-fast and between the best-fast samples are significant. The difference in time between the normal-best is not significant.

For Group II, the "t" tests are:

	Level of Significance
t12 = 3.7790	.01*
t13 = 1.2437	.25
t23 = 6.8656	beyond .01*

The differences for the normal groups between the three samples are similar to the behavior of the bright group. There are significant differences between normal-fast, best-fast, with no significant difference between normal-best.

For Group III, the "t" tests are:

	Level of Significance
t12 = 2.2891	.05*
t13 = .1713	.85
t23 = 2.5364	.03*

The results for Group III are similar to the time performance for Groups I and II but in lesser degree. There is a tendency here for the differences to become less among the three kinds of performance of the dull group.

* Significant at the 5% level.

Comparison of Time Performance of Three Groups in Respect to Normal, Fast, Best Samples.

Normal The "t" tests for the normal sample for the three groups are:

	Level of Significance
$t_{I,II} = .5555$	.60
$t_{I,III} = 2.1705$	.07
$t_{II,III} = 1.8114$	.10

The only differences which approach the criterion are the differences between the Bright-Dull, and the Normal-Dull Groups. There is no significant difference between the Bright-Normal in time on this sample.

Fast The "t" tests for the fast sample are:

	Level of Significance
$t_{I,II} = 1.2745$	.25
$t_{I,III} = 1.4563$	.15
$t_{II,III} = 2.1717$	.07

The similarity between the performance of the three groups on the normal sample and on the fast sample is striking. The same order of differences pertains here.

Best The "t" tests for the best sample for the three groups are:

	Level of Significance
$t_{I,II} = .4327$	.65
$t_{I,II} = 1.4156$	.15
$t_{II,III} = 1.2218$	.25

According to our criterion, none of the differences between the time performance of the three groups on the "best" sample are significant. There seems to be no reliable difference between the performance of the bright and normal group. This finding corresponds to the results obtained

in examining the performance on the normal and fast samples.

These findings for comparisons of different groups and their behavior on the same sample and the comparisons of the behavior of the same group on different samples can best be shown by Tables 6 and 7 on page 14.

Summary of Findings

1. For each of the three groups, their time performance on the normal-best samples tended to be the same.
2. For each of the three groups, there was a significant difference between the times for the normal- best samples and the fast.
3. When comparing the time performances of the three groups on the same sample, the performance of Groups I and II were very similar on Normal, Fast, and Best samples.
4. While no differences meet the 5% criterion, the differences in time performance approached significance when Groups I and II were compared to Group III in Normal, Fast and Best samples.

3. Judgments on Differences in Handwriting Performance of Bright, Normal, Dull Groups

Ordering of Best, Normal, Fast Handwriting Samples

It will be remembered that each subject after establishing the level of his writing of the writing task, wrote three samples under recording conditions; the first, his "normal" writing as it had been established by the prededing practice, the second, his fastest (the time for writing had to be 10 per cent less than the time for his normal writing), and finally, the third, his best handwriting allowing as much time as he wished to take. The previous data have established that the times for the production of these samples are significantly different, with the bright-normal group having more in common with each other than with the dull group.

Table 6

Comparisons Between Groups
"t" tests

Comparisons (group)	Levels of Significance Samples		
	N	F	B
I, II	.60	.25	.65
I, III	.07	.15	.15
II, III	.10	.07	.25

Table 7

Comparisons Between Samples
"t" tests

Comparisons by (sample)	Levels of Significance Groups		
	I	II	III
Normal Fast	.02*	.01*	.05*
Normal Best	.20	.25	.85
Fast Best	.01*	.01*	.03*

*Significant at 5% Level.

Subsequently after the subject had left the recording booth, he was asked to compare the handwriting samples obtained through the above conditions and to select the best, then the worst. The experimenter then marked the samples as being 1 (best), 2, 3 (worst). The nature of the comparison made was a relative one--each sample was compared with the others.

Two adults judged these same samples independently following the same instructions in order to provide an independent referent for comparing the ability of these groups of children to discriminate between the legibility of samples of their own handwriting. The value questions used were "Which one do you think is the best--the easiest to read?" "Which one do you think is the worst--the hardest to read?"

Table 8 shows the results of these judgments by the subjects and the two adult raters.

See Table 8 on page 16

Nature of Discriminations Made: By Subjects

The data presented by this table indicate that the subjects of this study did discriminate between their best, normal, and fast handwriting samples in the order indicated. This shows that a real difference existed between the means of the distribution of judgments, the greatest difference being between the Best and the Fast sample.

The t tests		Level of Confidence
1. Best	t12 = 2.3740	.02
2. Normal	t13 = 6.3896	beyond .01
3. Fast	t23 = 3.8775	beyond .01

By Judges

The ratings of the first judge showed that he was making significant discriminations between Best, Normal, Fast samples in the same order as the subjects. Again the greatest difference existed between the Best and the Fast samples.

Table 8

Judgments of Legibility of Best, Normal and Fast Samples*

Subjects	Child			Judge I			Judge II											
	B 1	N 2	F 3	B 4	N 5	F 6	B 7	N 8	F 9	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}	7^{th}	8^{th}	9^{th}
1	1	2	3	3	1	2	3	1	2	1	4	9	9	1	4	9	1	4
2	3	1	2	3	1	2	3	1	2	9	1	4	9	1	4	9	1	4
3	2	1	3	1	3	2	2	3	1	4	1	9	1	9	4	9	1	4
4	2	1	3	2	1	3	2	1	3	4	1	9	4	1	9	4	1	9
5	1	3	2	1	3	2	2	1	3	1	9	4	1	9	4	4	1	9
6	2	1	3	1	2	3	1	2	3	4	1	9	1	4	9	1	4	9
7	3	1	2	1	3	2	1	3	2	9	1	4	1	9	4	1	4	9
8	3	1	2	1	2	3	1	2	3	9	1	4	1	4	9	1	4	9
9	1	3	2	1	2	3	2	1	3	1	9	4	1	4	9	1	4	9
10	2	3	1	1	2	3	1	2	3	4	9	1	1	4	9	1	4	9
11	1	2	3	2	1	3	1	2	3	1	4	9	4	1	9	1	4	9
12	1	2	3	1	3	2	3	1	2	1	4	9	1	9	4	9	1	4
13	1	2	3	1	2	3	2	1	3	1	4	9	1	4	9	4	1	4
14	1	2	3	2	1	3	1	2	3	1	4	9	4	1	9	1	4	9
15	1	2	3	1	2	3	2	1	3	1	4	9	1	4	9	4	1	9
16	1	3	2	1	2	3	3	2	1	1	9	4	1	4	9	1	4	9
17	1	3	2	1	2	3	1	2	3	1	9	4	1	4	9	1	4	9
18	1	3	2	2	3	1	3	2	1	1	9	4	1	4	9	1	4	9
19	1	2	3	1	2	3	1	3	2	1	4	9	1	4	9	1	4	9
20	3	2	1	3	2	1	3	1	2	9	4	1	9	4	1	9	1	4
21	1	2	3	1	2	3	1	2	3	1	4	9	1	4	9	1	4	9
22	1	2	3	1	2	3	2	1	3	1	4	9	1	4	9	1	4	9
23	1	2	3	2	1	3	1	3	2	1	4	9	4	1	9	1	4	9
24	1	2	3	1	3	2	1	3	2	1	4	9	1	4	9	1	4	9
25	1	2	3	2	1	3	1	3	2	1	4	9	1	4	9	1	4	9
26	1	2	3	1	3	2	1	3	2	1	4	9	1	4	9	1	4	9
27	2	1	3	1	2	3	3	1	2	4	1	9	1	4	9	1	4	9
28	2	1	3	1	2	3	1	2	3	4	1	9	1	4	9	1	4	9
29	2	1	3	1	2	3	2	1	3	4	1	9	1	4	9	1	4	9
30	2	1	3	1	3	2	1	2	3	4	1	9	1	9	4	1	4	9
Sum	47	58	78	42	61	77	52	55	73	86	120	214	72	139	209	110	119	191
Ave	1.57	1.93	2.6	1.4	2.03	2.57	1.73	1.93	2.43	2.87	4.0	7.13	2.40	4.63	6.96	3.67	3.97	6.37
σ	.64	.53	.608	.659	.714	.60	.82	.79	.686									

*Ratings by subject and two judges, sample against sample.

1x4	1x7	2x5	2x8	3x6	3x9	4x7	5x8	6x9
3	3	2	2	6	6	9	1	4
9	9	2	1	6	6	9	1	4
2	4	3	3	6	3	2	9	2
4	4	1	1	9	9	4	1	9
1	2	9	3	4	6	2	3	6
2	2	2	2	9	9	1	4	9
3	3	3	3	4	4	1	9	4
3	3	2	2	6	6	1	4	9
1	2	6	3	6	6	2	2	9
2	2	6	6	3	3	1	4	9
2	1	2	4	9	9	2	2	9
2	1	3	2	6	6	3	3	4
1	2	1	2	9	9	2	2	9
2	1	2	4	9	9	2	2	9
1	2	4	2	9	9	2	2	9
1	3	6	6	6	2	3	4	3
1	1	6	6	6	6	1	4	9
2	3	9	6	2	2	6	6	1
1	1	4	6	9	6	1	6	6
9	9	4	2	9	2	9	2	2
1	1	4	4	9	9	1	4	9
1	2	4	2	9	9	2	2	9
2	1	2	6	9	6	2	3	6
1	1	6	6	6	6	1	9	4
2	1	2	6	9	6	2	3	6
1	6	2	6	6	6	1	9	4
2	2	2	1	9	6	3	2	6
2	4	2	2	9	9	1	4	9
2	2	3	2	9	9	2	2	9
2	2	3	2	9	9	1	6	6
67	80	116	104	206	193	79	115	194
2.23	2.66	3.87	3.46	6.87	6.4-	2.63	3.83	6.46

The t tests were:

Column of Ranks by First Judge		Level of Confidence
4 = B	t45 = 3.5532	beyond .01
5 = N	t46 = 7.1911	beyond .01
6 = F	t56 = 3.1727	beyond .01

The second judge did not make significant differentiations between the Best and Normal samples but did between the Best and Fast and between Normal and Fast.

The t tests were:

Column of Ranks by Second Judge		Level of Confidence
7 = B	t78 = .4812	.65
8 = N	t79 = 3.5860	beyond .01
9 = F	t89 = 3.1413	beyond .01

Comparisons Between Subjects and Judges On Best, Normal, Fast Samples

	Best	Confidence Level
1 = Subject	t14 = 1.0216	.30
4 = 1st Judge	t17 = .8425	.40
7 = 2nd Judge	t47 = 1.7205	.10
	Normal	**Confidence Level**
2 = Subject	t25 = .5265	.60
5 = 1st Judge	t28 = .5770	.55
8 = 2nd Judge	t58 = 1.0288	.30
	Fast	**Confidence Level**
3 = Subject	t36 = .1619	.90
6 = 1st Judge	t39 = 1.0155	.30
9 = 2nd Judge	t69 = .8418	.40

The reader should remember that the larger the size of the "t" value the greater chance that a significant difference exists between the means being compared. As the size of "t" increases, the confidence level approaches and exceeds the 1% level. As the "t" value gets smaller the confidence level approaches 100% certainty that no real difference exists between the means. In our exploratory study we are using the 5% level as an arbitrary level of confidence.

These data support the following conclusions:

1. The subjects and the two judges made significant discriminations between Best, Normal, Fast samples in the order indicated (best being judged the best, fast poorest, and normal inbetween). The one exception was the second judge who did not discriminate between the best and normal samples.

2. When ratings of Best samples were compared, all did not reach the criterion 5% indicating similarity of rating, the greatest difference was between the two judges, the greatest similarity was between the subjects' rating and the second judge.

3. When ratings of normal samples were compared, all were substantially beyond the criterion 5% but again the greatest difference occurred in the comparison of the ratings of the two judges.

4. In comparing the judging of the fast samples the subjects and judges were in their greatest agreement, with the subjects and the first judge in general agreement and the subjects and the second judge in the least.

Their findings were further checked by reviewing the product-moment correlations for these data:

r14 = .07	r28 = -.17	r69 = .509
r17 = -.09	r36 = +.33	r58 = .212
r25 = -.13	r39 = .31	r47 = .319

	Subject	CODE 1st Rater	2nd Rater
Best	1	4	7
Normal	2	5	8
Fast	3	6	9

Implications of these Findings for Study

1. The "t" tests and the correlations substantiate the ability of the subjects to discriminate among their writing samples. These discriminations were primarily between the best-normal and the fast samples.

2. The correlations show the greater relationship between the judges than between the subjects and the judges. This was not true, however, for the fast samples where the greatest agreement was found in all the ratings.

3. The problem of training and instructing judges is evident in the results. Although, if larger groups are used and the range of scores were extended beyond 3, the correlation would be much higher.

4. The relative ability of the three groups to make these judgments should be examined in the major sample. The adequacy of our ratings by judges did not merit the further analysis of this factor in these data. The children in Group III had great difficulty in making these judgments. Data in section 5 will substantiate this observation.

5. Many of the children in Group III could not reproduce the visual handwriting stimulus but stabilized their own version of it. Comparison of the writing quality of their "versions" of "the fox jumped" would be difficult for anyone. The adult judges had similar difficulty.

4. Analysis of the Polygraph Records.

In addition to data secured from the samples directly and from judgments made by subjects about their handwriting samples, an attempt was made to secure

objective data on behavior during the act of handwriting. Previous investigations of adult and children's handwriting suggested that the pressure pattern of the pen point in handwriting might be related to such factors as the rate and legibility of handwriting. Furthermore, since the act of handwriting presumably involves a change in the tension state of the subject, an attempt was made to secure two types of indices of tension phenomena, muscle action-potentials and the psycho-galvanic reflex, both taken from the non-writing arm. It will be recalled that our original hypothesis was that children in the three groups would behave in essentially the same way with respect to these types of data.

Of the three types of data secured on the polygraph records--handwriting point pressure, muscle action-potentials, and the psycho-galvanic reflex (PGR)--only the point pressure and PGR records were suitable for analysis. Technical difficulties, now overcome, produced inadequate action-potential records. Likewise, since the polygraph data depend for analysis upon the completion of the cursive writing assignment, "the fox jumped," only groups I and II of the original sample could be analyzed.

The Force Variation Ratio

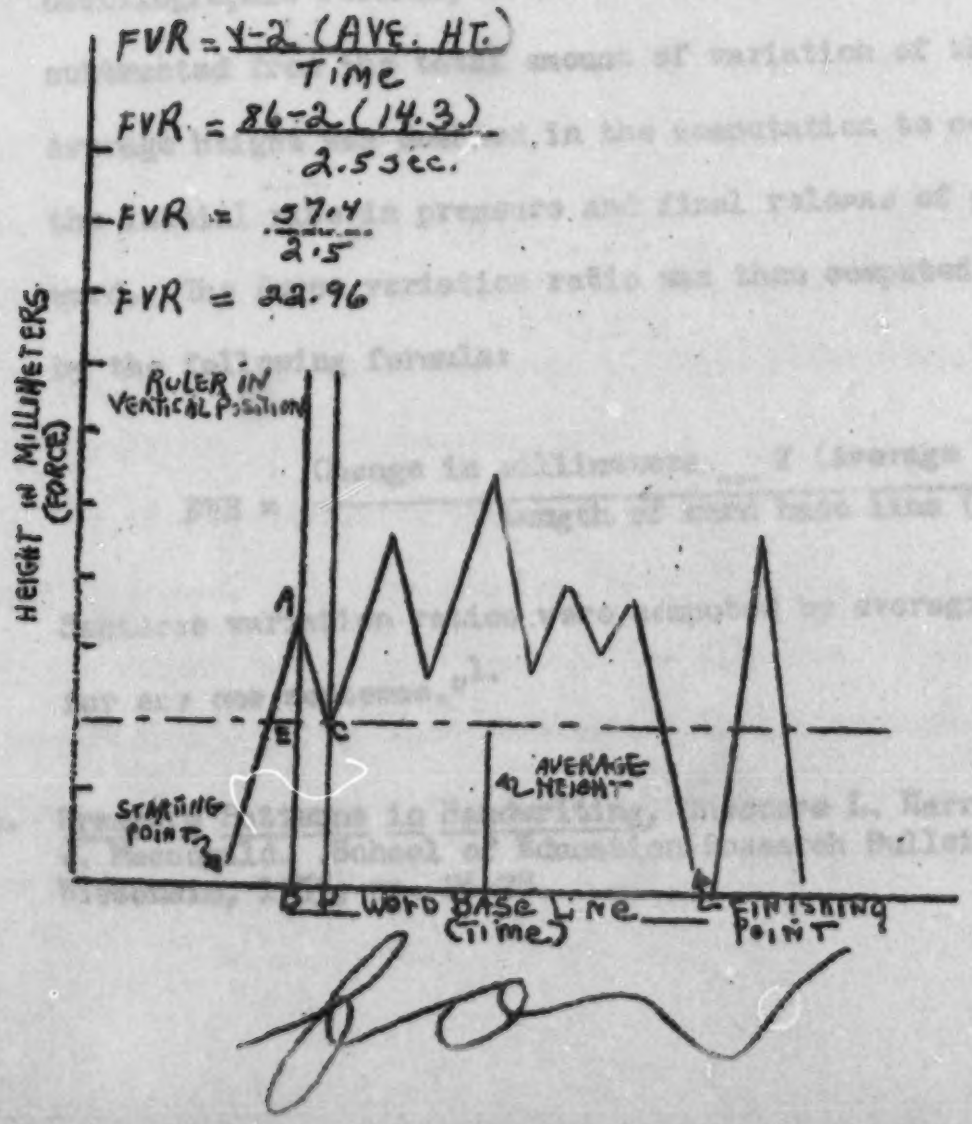
The force variation ratio, described in an earlier publication, "Pressure Patterns in Handwriting," was originally devised to allow a more adequate interpretation of variability in force among pressure records than a comparison of average pressure alone would allow. This ratio was thus described in the original bulletin:

> "Variability in force.--Inspection of oscillographic records of the same or similar average force showed marked differences in the characteristics of the force curves. For example, two pressure records of almost identical average force might in one case show extreme fluctuations.

In order to describe these differences quantitatively, a measure of variability of force was devised. Variability in force was taken to be the cumulative amount of change in direction of force measured vertically from the base line. The number of measurements taken on a given record depended upon the number of times the direction of the force curve changed to the extent of one millimeter measured in a direction parallel to the base line. Slight changes in direction of pressure less than one millimeter were not thought to be significant. Variability in force thus measured represents an attempt to describe differences in the total amounts of deviation from the baseline for the word or sentence.

The specific method of determining variation in force is illustrated in Figure 2. A metric ruler was moved from left to

Figure 2



right at right angles to the base line until the point at which the pressure curve first changed direction was reached. The vertical distance from this point A to the base line was noted. The ruler was then moved to the next point C on the pressure curve denoting a change in direction and the vertical distance was again measured. The change in pressure was derived by subtracting CD from AB. This difference represents the vertical distance between the two points AE. Measurement continued in this manner until the curve rested upon the base line at the end of the word. The total amount of change thus measured for each word and sentence was calculated. It should be noted that the dotting of the i's and the crossing of the t's and the x's were not included in the variability measure.

In order to equalize differences in the average pressure of the oscillographic records, twice the average height in each word was subtracted from the total amount of variation of the force curve. Average height was doubled in the computation to compensate for the initial rise in pressure and final release of pressure for each word. The force variation ratio was then computed for each word by the following formula:

$$FVR = \frac{\text{Change in millimeters} - 2\ (\text{Average height})}{\text{Length of word base line (Time)}}$$

Sentence variation ratios were computed by averaging the word ratios for any one sentence."[1]

1. Pressure Patterns in Handwriting, Theodore L. Harris, G. L. Rarick, and J. Macdonald. School of Education Research Bulletin, University of Wisconsin, 1955, pp. 26-28.

Since the force variation ratio is a ratio obtained by dividing the cumulative amount of change in pressure by time, it is possible to compare pressure records that vary greatly in the amount of time taken to produce them.

In Table 9 on page 24 the force variation ratios are given for the normal, fast, and best samples of all boys and girls in Groups I and II. Since the number of cases is small in this case, the major type of analysis made is that of examining the significance of the differences of the means between the various types of groupings. These data are shown in Table 10 on page 25.

The data from this table enable us to describe the extent of differences in variability of pressure (1) between Groups I and II, by total subjects and by sex, for each type of sample; (2) between sexes for each type of sample within groups; and (3) between samples for total groups and by sex within groups.

Comparisons between Groups I and II fail to show significant differences at the 5% level for either the total groups or for separate sexes. Comparisons between boys and girls respectively within Groups I and II were not significant at the 5% level except between the best samples of boys and girls in Group II. In the latter case the mean force variation ratio was significantly greater for girls than boys.

In 18 comparisons of normal with fast samples, of fast with best samples, and of normal with best samples, by groups and by sex within groups, only 4 comparisons were significant at the 5% level. Each of the 4 significant comparisons involved fast samplesin relation to normal or best samples. The finding of the greater force variation of the fast sample is in keeping with previous research findings.

Table 9

Force Variation Ratios for the Normal, Fast and Best Samples of Boys and Girls in Groups I and II

	Normal	Fast	Best
Subject	FVR	FVR	FVR
16IFa	1.55	1.92	1.32
22IFa	2.09	4.56	2.57
23IFa	.36	3.11	1.71
27IFa	1.23	1.74	1.33
30IFa	2.89	5.53	2.84
Mean (Fa)	1.62	3.37	1.95
21IMa	1.02	.67	.56
24IMa	1.92	2.03	1.95
25IMa	1.48	2.80	1.54
28IMa	2.45	5.39	2.86
29IMa	4.76	4.54	2.04
Mean (Ma)	2.33	3.09	1.79
Total Mean(I)	1.98	3.23	1.87
6IIFa	4.64	5.99	3.49
9IIFa	1.70	4.22	1.71
12IIFa	2.10	2.64	2.55
13IIFa	3.13	5.76	4.56
19IIFa	3.16	6.55	3.41
Mean (Fa)	2.95	5.03	3.14
1IIMa	2.16	2.50	2.23
4IIMa	1.52	2.65	.91
11IIMa	1.33	1.56	1.17
15IIMa	1.85	3.11	2.03
26IIMa	4.14	6.85	2.15
Mean (Ma)	2.20	3.33	1.70
Total Mean(II)	2.57	4.18	2.42

Table 10

Significance of the Differences Between the Means of the Force Variation Ratio for Various Types of Groupings of Subjects*

Groups	t value	Significance at 5% level
Between Groups I & II		
Total N	1.120	Not Significant
" F	1.170	" "
" B	1.297	" "
Boys N	—	" "
" F	—	" "
" B	—	" "
Girls N	2.006	" "
" F	1.627	" "
" B	2.073	" "
Between Boys I & Girls I		
N	—	" "
F	—	" "
B	—	" "
Between Boys II & Girls II		
N	1.040	" "
F	1.466	" "
B	2.638	Significant
Between N & F		
Total Group I	1.903	Not Significant
Boys I	.710	" "
Girls I	2.056	" "
Total Group II	2.258	Significant
Boys II	1.087	Not Significant
Girls II	2.374	Significant
Between F & B		
Total Group I	2.341	Significant
Boys I	1.398	Not Significant
Girls I	1.761	" "
Total Group II	2.479	Significant
Boys II	1.707	Not Significant
Girls II	2.203	" "
Between N & B		
Total Group I	—	" "
Boys I	.716	" "
Girls I	.625	" "
Total Group II	—	" "
Boys II	.870	" "
Girls II	—	" "

*Comparisons between total groups by samples and by sex involve comparisons of 10 subjects each. Other comparisons of sex against sex involve only 5 subjects each.

Implications of the Force Variation Ratio Data

These results suggest, however, that true differences from chance in the force variation ratios for these small samples are but few, and that when they exist, they tend to be associated with rate of writing. The differences that do exist at the 5% level, likewise represent differences between the fast-best or the fast-normal samples in 4 out of 5 cases, and in only 1 case represent sex differences. The latter data indicate that we may expect more significant differences in the force variation ratio between samples of bright, normal, and possibly dull children than between sexes within these groups. The differences between Groups I and II as a whole, likewise, are not consistent enough nor large enough to warrant the abandonment of our original hypothesis.

The Psycho-Galvanic Reflex

The psycho-galvanic reflex was used in this exploratory study as one measure of tension. It was thought, for example, that the act of writing might be expected to produce a greater state of bodily tension than would exist in the pre and post writing stages; and that increased activity of the PGR would give one type of evidence of such a state of tension.

The use of the PGR as one index of bodily tension during the complicated and sustained handwriting act posed a number of problems. Certain of these, such as establishing a baseline (normal resistance between two electrodes) and measuring the frequency and amplitude of the PGR activity, are common to all studies of the PGR. Others, such as the high speed at which the record was taken, the determination of the segments to be examined, and the types of measurements needed to interpret the data quantitatively, are particular to our problem. These problems will be discussed briefly before the data are presented for analysis.

During the preliminary trials in learning to reproduce the stimulus, adjustments were made on the polygraph to attempt to stabilise the baseline

for the individual subject. Similarly, the waiting period between the last preliminary trial and the first normal record was sometimes extended to allow the individual's PGR baseline to "settle." Due to individual variations in our subjects, however, we were not equally successful in establishing clear-cut baselines for all individuals. This presented a distinct problem for which specific procedures for analysis were devised.

The high speed at which the polygraph was operated in order to secure an adequate point pressure record introduced a second complication in the interpretation of the PGR records. Specific techniques of measurement and interpretation of records taken at 1/10 or less the speed of our records would hardly appear appropriate for our use. Indeed, our records look very different from conventional PGR records because the usual steep rise to a peak( ) looks more like a mild slope of a hill ( ). We have nevertheless found it useful to consider the number and the magnitude of PGR peaks in the handwriting segment of the record in relation to segments immediately preceding and following the handwriting.

Methods of Analysis of the PGR

Three segments were laid off on the PGR record in relation to each sample point pressure record: (1) the writing phase, a segment paralleling the point pressure record, (2) the preparatory phase, a segment equivalent in length to the writing phase, laid off immediately preceding the onset of writing, and (3) the post-writing phase, a segment of three second's duration immediately following the writing phase. The preparatory phase was used to provide an equivalent time period of comparative rest for comparison with the active writing phase. The post writing phase was abbreviated since the primary purpose here was simply to determine if a change in PGR activity was associated with the cessation of writing.

After the three PGR segments were determined, a baseline was drawn.

The baseline was drawn parallel to the edge of the record and was established, in so far as possible, as a line of best fit to the lowest stable PGR activity during the writing and preparatory phases. The height of this baseline was measured for each sample.

Measurements were next taken of deviations in the PGR above the established baseline. In this exploratory study, a deviation of one millimeter upward with a corresponding return of one millimeter measured vertically from the baseline, was taken to define a peak. The number of peaks was next counted in each segment for each sample, and two types of measurements were taken for each peak: (1) the distance from the onset of writing, and (2) the height of each peak above the baseline. These measurements of the number and amplitude of PGR peak activity in relation to the onset and cessation of writing constitute the basic data in the interpretation of results.

Results of the PGR Data

Stability of the PGR Baseline for Individuals. Table 11 on page 29 shows that some variability exists in the height of the established PGR baselines for the successive samples of individuals although differences between the highest and the lowest baseline for an individual is typically two millimeters or less. There is no perceivable trend in the direction of differences in baseline height for the normal, fast and best samples of individuals. Differences in the average height of the baseline between Groups I and II, and between normal, fast, and best samples within and between groups, average less than a millimeter and are negligible.

Frequency of Peaks per Segment. Data for the frequency of peaks per segment are given in Table 12 on page 30. Since only the preparatory and writing segments represent equivalent time segments, the basic comparisons in number of peaks will be made for these segments first. The analysis of the post writing phase will then be made separately.

Table 11

Height of PGL Baseline (in cm.) for Normal, Fast, and Best Samples

Subjects	Normal	Fast	Best
Group I			
16 I Fa	.85	.75	.65
22 I Fa	.50	.45	.50
23 I Fa	.65	.50	.55
27 I Fa	.65	.70	.70
30 I Fa	.50	.60	.50
21 I Ma	.70	.50	.45
24 I Ma	.70	.75	.55
25 I Ma	.75	.45	.60
28 I Ma	.40	.60	.60
29 I Ma	.80	.70	.80
Mean	.65	.60	.59
Group II			
6 II Fa	.20	.20	.25
9 II Fa	.40	.90	.90
12 II Fa	.75	.75	.60
13 II Fa	.70	.70	.80
19 II Fa	.70	.70	.70
1 II Ma	.50	.70	.45
4 II Ma	.60	.60	.60
11 II Ma	.40	.50	.60
15 II Ma	.30	.70	.20
26 II Ma	.60	1.10	.90
Mean	.52	.69	.60

Table 12

Number of PGR Peaks for Each Segment of Each Sample in Groups I and II

Subjects	Normal			Fast			Best			Σ of Peaks		
Group I	Prep	Writ	Post	Prep	Writ	Post	Prep	Writ	Post	Prep	Writ	Post
16 I Fa	3	5	1	3	3	1	2	4	1	8	12	3
22 I Fa	1	1	1	1	2	2	7	2	2	9	5	5
23 I Fa	2	1	1	1	3	2	3	2	1	6	6	4
27 I Fa	3	3	1	3	4	2	2	3	2	8	10	5
30 I Fa	2	2	1	2	2	1	3	2	1	7	6	3
21 I Ma	1	2	2	2	1	2	2	2	1	5	5	5
24 I Ma	6	3	1	4	3	0	4	4	1*	14	10	2
25 I Ma	3	1	2	3	1	3	2	2	1	8	4	6
28 I Ma	4	1	1	3	1	2	3	2	1	10	4	4
29 I Ma	0	2	1	0	1	3	1	1	1*	1	4	5
Mean	2.5	2.1	1.2	2.2	2.1	1.8	2.9	2.4	1.2	7.6	6.6	4.2
Group II												
6 II Fa	5	1	0	4	0	1	5	0	0	14	1	1
9 II Fa	1	2	2	1	2	3	3	0	1	5	4	6
12 II Fa	1	1	1	0	1	2	3	0	2	4	2	5
13 II Fa	3	1	1	1	2	2	2	1	1	6	4	4
19 II Fa	1	1	1	2	0	1	1	1	0	4	2	2
1 II Ma	0	0	0	3	2	0	3	2	1	6	4	1
4 II Ma	4	2	1	4	3	0	4	5	0	12	10	1
11 II Ma	3	1	2	5	2	2	5	3	1	13	6	5
15 II Ma	3	1	2	0	1	2	2	4	1	5	6	5
26 II Ma	4	2	1	1	1	2	3	1	1	8	4	4
Mean	2.8	1.3	1.4	2.6	1.8	1.9	3.1	2.4	1.1	7.7	4.3	3.4

* Post writing phase is less than 9 cm.

1. The Preparatory and Writing Segments

In comparing the number of peaks in the preparatory and writing segments, it will be noted that the average number of peaks for each sample tends to be greater in the preparatory than in the writing phase. This is also true for the average number of peaks for the summation of normal, fast and best samples in Groups I and II.

For Group I, the average difference in the number of peaks is one-third of a peak greater in the preparatory phase; but when the average of the total number of peaks for normal, fast and best samples is examined the average difference is one (1.0) peak. For Group II the average difference is one (1.0) peak greater in the preparatory phase, but for the average of all peaks for normal, fast, and best samples, is three and four tenths (3.4) peaks greater.

It would thus appear that there is consistently greater PGR activity in the preparatory phase than in the writing phase for all samples insofar as the frequency of peaks in the PGR record is concerned. Furthermore, differences in such activity tend to be greater for Group II than for Group I in terms of the above comparisons.

Examination of this same table with respect to an individual's pattern of peak PGR activity from normal to fast to best samples shows wide variation in peak frequency relative to the preparatory and writing segments. For example, in only two cases out of the combined group of 20 subjects were the number of peaks greater in the preparatory than the writing phase for each sample of the individual (subjects 6 and 11). No other combination of patterns other than those involving ties or equal frequency, for the normal, fast and best samples appeared to represent more than a single individual. Differences in average peak frequency of these segments between groups appear to be very slight (less than half a peak) except in two instances. Average peak frequency of the normal writing segment for Group I was found

to be two and one-third peaks greater for the writing phase than in Group I.

2. The Post-Writing Segment

Examination of data in Table 12(on page 30) for the post-writing phase clearly shows that some measurable peak activity occurred within three seconds of the cessation of writing in 52 out of 60 samples gathered. It will also be noted that while the average number of peaks occurring in this phase tends to be only slightly over one peak for normal and best samples, the average number of peaks for fast samples is closer to two peaks (1.8 and 1.9 peaks, respectively). Group I on the average shows .8 more of a peak than does Group II in this phase.

In the foregoing analysis of the frequency of peak PGR activity in the preparatory, writing and post-writing phases of the study, there appears to be evidence that the number of changes in a positive direction suggestive of increased tension is greater in the preparatory than in the writing phase. There also appears to be evidence that when the writing act ceases, there is a similar positive change in tension state. Since the number of changes alone have perhaps only limited significance, the degree or magnitude of such changes will also be examined in the next section.

Average Height of Peaks per Segment. Data on the height of peaks for the preparatory, writing and post-writing phases is given in Table 13 on page 33. It is appropriate in this case to compare the average heights of each of the three segments since equivalent time segments are not critical in determining the magnitude of a PGR peak in this study.

It should be noted first of all that the data, which are reported in centimeters, represent in two-thirds of the cases fractional parts of a centimeter. In other words, most of the average heights reported are relatively small, and tend to cluster around a height of one-half a centimeter. Since the smallest unit of measurement in our computations was the millimeter, it will be readily seen from the table that these differences in the fractional parts of a centimeter are very small indeed for the grouped data.

. Table 13

Average Height in Cm. of PGR Peaks for Each Segment of Each Sample in Groups I and II

Subjects	Normal			Fast			Best			Average Height of all Peaks		
Group I	Prep	Writ	Post	Prep	Writ	Post	Prep	Writ	Post	Prep	Writ	Post
16 I Fa	.68	.70	.10	.80	.65	.30	.83	.36	.30	.76	.58	.23
22 I Fa	.70	.80	.70	.30	.25	.65	.37	.10	1.00	.40	.30	.80
23 I Fa	.28	.70	.20	.60	.48	.35	.57	.40	.10	.48	.49	.25
27 I Fa	.33	.32	.45	.42	.23	.38	.58	.22	.35	.43	.25	.38
30 I Fa	1.13	1.08	.60	.78	.85	.10	.62	.23	.80	.81	.72	.50
21 I Ma	.80	.55	.50	.50	.50	.63	1.00	.53	.35	.76	.53	.52
24 I Ma	.43	.48	.50	1.03	.28	.00	.36	.45	.30	.58	.41	.40
25 I Ma	.62	.20	1.10	.52	.10	.45	.13	.20	1.05	.46	.18	.77
28 I Ma	.92	.75	.55	.52	.80	.38	.37	.50	.10	.54	.64	.35
29 I Ma	.00	.35	.25	.00	.80	.22	.20	.40	.20	.20	.48	.22
Median Average Height	.65	.63	.50	.52	.49	.37	.47	.38	.33	.51	.49	.39
Group II												
6 II Fa	1.87	.50	.00	.73	.00	.15	.58	.00	.00	1.08	.50	.15
9 II Fa	.80	1.23	1.00	.45	.98	.95	.78	.00	.40	.72	1.10	.88
12 II Fa	.30	.80	.85	.00	1.15	.10	1.30	.00	1.05	1.05	.98	.63
13 II Fa	.15	.55	.60	.60	.40	.30	.48	.45	2.05	.33	.45	.81
19 II Fa	.50	.40	.15	.40	.00	.50	.40	.10	.00	.43	.25	.33
1 II Ma	.00	.25	.00	.28	.48	.00	.40	.50	.25	.34	.49	.25
4 II Ma	.30	.18	.25	.16	.20	.00	.26	.21	.00	.24	.20	.25
11 II Ma	.95	1.15	.40	.55	.78	.28	.50	.38	.70	.62	.64	.41
15 II Ma	.73	.40	1.65	.00	.10	.70	.88	.23	2.05	.79	.23	1.35
26 II Ma	1.00	.23	1.40	.25	.10	1.05	.62	.15	1.60	.76	.18	1.28
Median Average Height	.62	.45	.50	.34	.30	.29	.54	.18	.55	.67	.47	.52

Keeping these qualifying factors in mind, it may be noted that in examining the median of average height figures for normal, fast, and best samples, the highest median occurs in five out of six cases in the preparatory phase. In only best samples in Group II does the highest median figure fall in another segment; in this case, in the post phase. Similarly, the lowest median figure is that for the post phase in four out of six cases. The median of average height figures in Group I show a slight but consistent decline from the preparatory to writing to post-writing phase. Such a tendency is not noticeable in Group II except in the data for the fast sample and for the median figures of the average height of all peaks. However, since the differences between the highest and lowest median figure for average height of PGR peaks typically do not exceed one and one-half millimeters, the significance of these differences is exceedingly doubtful.

Characteristics of the First PGR Peak in the Writing Phase. An aspect of the record which was considered important to examine was the determination of the distance and average height of the first peak after the onset of writing. The data for this activity are given in Table 14 on page 35.

These data show, for example, a parallel and consistent decline in the average height of the first peak as subjects in both groups moved from normal to fast to their best samples. On the other hand, Groups I and II show a reverse pattern when the average distance from the onset of writing is considered. That is, Group I peaks at a substantially later point on the average for the fast sample than for the normal and best samples; while in Group II, the peak of the fast sample is reached much earlier on the average than is that for the normal and best samples.

If the question of how soon, in terms of seconds, did a peak of PGR activity occur, reference to Table 15 on page 36 is useful. This table

Table 14

Distance and Height of the First PGR Peak After the Onset of Writing for the Normal, Fast and Best Samples in Groups I and II

Subjects	Normal		Fast		Best	
	Distance	Height	Distance	Height	Distance	Height
Group I						
16 I Fa	2.9	1.3	2.9	1.1	3.9	.6
22 I Fa	2.0	.8	3.4	.2	2.3	.1
23 I Fa	2.9	.7	1.2	.5	2.2	.5
27 I Fa	2.5	.5	3.1	.4	2.1	.2
30 I Fa	4.3	1.3	4.1	1.1	3.6	.3
21 I Ma	2.7	.9	.1	.5	3.3	.5
24 I Ma	1.9	.7	2.7	.3	3.4	.6
25 I Ma	1.3	.2	12.9	.1	1.0	.2
28 I Ma	2.6	.8	4.1	..8	3.6	.6
29 I Ma	4.1	.5	7.5	.8	1.2	.4
Mean	2.72	.77	4.20	.58	2.86	.40
Group II						
6 II Fa	10.4	.5	0.0	0.0	0.0	0.0
9 II Fa	3.5	2.2	4.7	1.4	0.0	0.0
12 II Fa	4.9	.8	3.6	1.2	0.0	0.0
13 II Fa	1.5	.6	.9	.5	.9	.5
19 II Fa	3.3	.4	0.0	0.0	3.9	.1
1 II Ma	4.4	.3	3.5	.5	4.9	.6
4 II Ma	15.6	.2	1.2	.2	3.5	.3
11 II Ma	3.2	1.2	3.4	1.1	1.0	.8
15 II Ma	5.9	.4	1.8	.1	.6	.6
26 II Ma	9.6	.1	1.8	.1	26.1	.2
Mean	6.23	.69	2.30	.50	4.10	.30

Table 15

Frequency of Occurrence of the First PGR Peak After the Onset of Writing

	1 sec.	2 sec.	3 sec.	4 or more sec.	no peak activity
Normal					
Group I	8	2			
Group II	1	6		3	
Total	9	8		3	
Fast					
Group I	4	4	1	1	
Group II	3	5			2
Total	7	9	1	1	2
Best					
Group I	4	6			
Group II	3	3		1	3
Total	7	9		1	3
Total					
Group I	16	12	1	1	
Group II	7	14		4	5
Total	23	26	1	5	5

shows that peak activity occurred in 82 per cent of the cases within two seconds of the onset of writing, and that this peak activity tended to occur earlier for Group I (during the first second) and later for Group II (from one to two seconds).

Implications of the PGR Analysis

It would appear, in retrospect, that comparisons of the preparatory, writing, and post-writing phases is a useful means of analysis of PGR activity provided that greater control can be placed over the subjects' behavior for a reasonable length of time before and after writing. In particular, the subjects need to assume a relatively restful or quiescent attitude.

Such precautions should enable us to establish a more stable and representative baseline than was possible in all cases in the exploratory analysis of PGR data.

It should also be noted that the findings of greater PGR activity in the preparatory phases than in later phases may be partly a function of this lack of control during this phase and partly a function of accomodation to the writing task.

It may likewise be possible in a future study to devise a workable and useful ratio between PGR peak location and amplitude in relation to the onset of writing in order to bring these two factors into a more meaningful relation to each other.

In view of the nature of the PGR data, it would seem that data for individuals should receive primary consideration in the analysis and that inter-personal and inter-group comparisons should receive less emphasis. Certainly it is difficult to interpret with confidence at this time the significance of observed PGR differences between Groups I and II. There is reason to believe, however, that we can measure the frequency and degree of

peak PGR activity in relation to the handwriting act and to describe its function in relation to such aspects of the task as the preparatory writing set, the writing act itself, and the cessation of writing. With the recording of adequate muscle-action potentials in the next phase of the study, it may be possible to use both the PGR and the action-potential data to more adequately describe the points and magnitude of tension evoked by the complex act of handwriting.

Legibility and the Force Variation Ratio

The samples were ranked, sample against sample, in order of legibility. The ranking was done for normal, fast and best samples separately, and for each sex within Group I and Group II. There were thus twelve sets of rankings, as shown in Table 16 on page 39. The ranking was done initially by two experienced handwriting raters with perfect agreement in six of the twelve sets of rankings; with the displacement of just two adjoining samples in four of the remaining six sets; and with the displacement of more than two samples in only two sets. A third experienced rater was then used to resolve the initial differences in ranking.

Considerable stability may be observed in the rank order of legibility for individuals as they moved from their normal to fast to best samples. For example, the four pupils who ranked first in legibility on one sample also ranked first on their fast and best samples, while in three additional cases (22, 29, 11), the same rank order was maintained in each set of rankings. Thus seven out of the twenty sets of rankings were completely consistent. In addition, in eleven out of the remaining thirteen sets of rankings, the same rank order was maintained in two out of three sets.

When the rank order for legibility is compared with that for the force variation ratio as shown in Table 17 on page 40, little apparent relationship may be noted within the twelve sets of rankings. This is illustrated graphically in Figures 3, 4, and 5 on pages 41, 42, and 43, respectively. The boys of

Table 16

Ranking of Legibility, Sample Against Sample, by Sex Within Groups

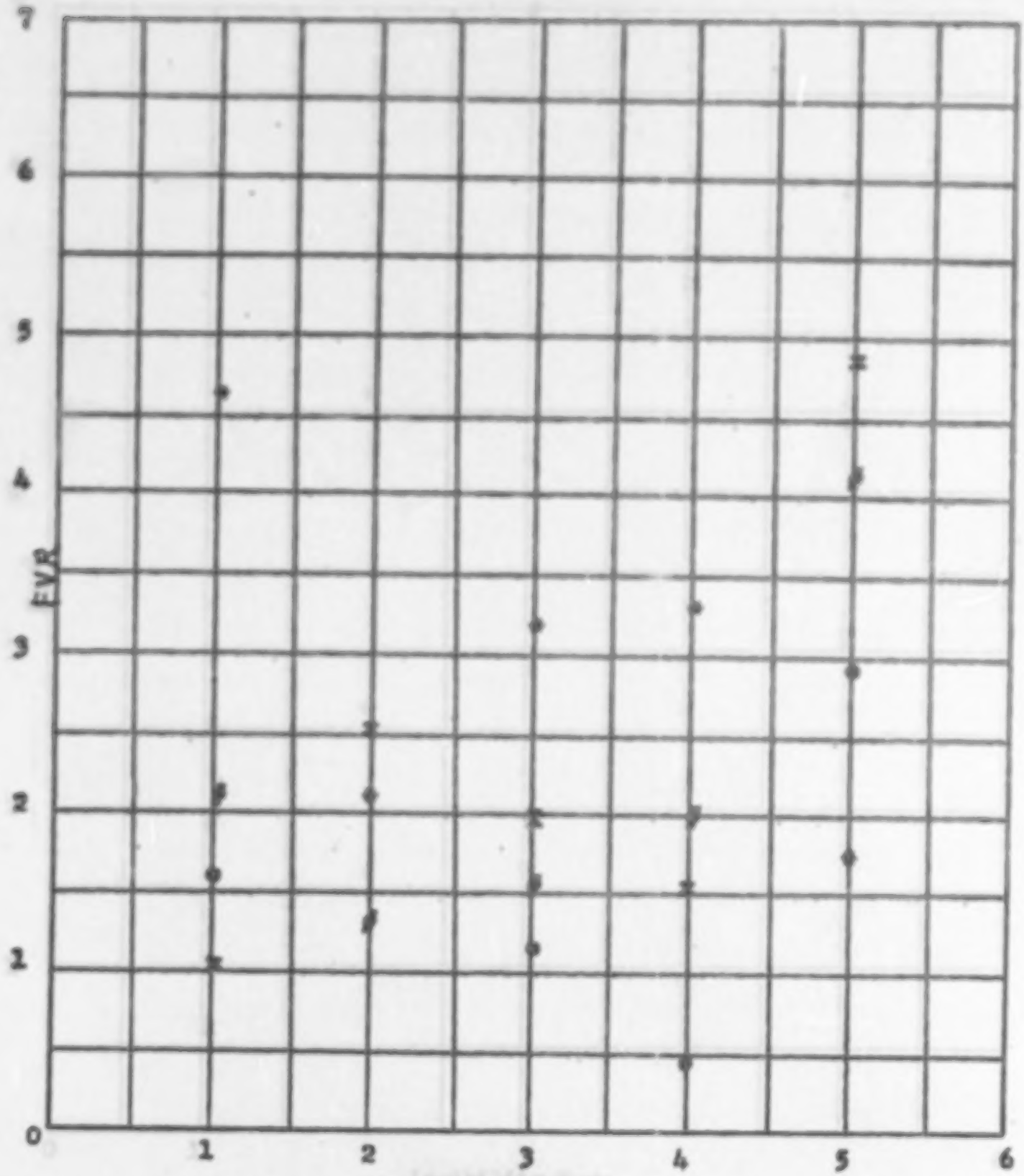
Subject	Normal Final rank	Fast Final rank	Best Final rank
Group I			
16 I Fa	1	1	1
22 I Fa	2	2	2
23 I Fa	4	5	3
27 I Fa	3	3	4
30 I Fa	5	4	5
21 I Ma	1	1	1
24 I Ma	3	2	2
25 I Ma	4	3	3
28 I Ma	2	4	4
29 I Ma	5	5	5
Group II			
6 II Fa	1	1	1
9 II Fa	5	3	5
12 II Fa	2	2	4
13 II Fa	3	5	3
19 II Fa	4	4	2
1 II Ma	1	1	1
4 II Ma	3	4	4
11 II Ma	2	2	2
15 II Ma	4	5	3
26 II Ma	5	3	5

Table 17

Legibility and Force Variation Ratio data by Sex for Groups I & II

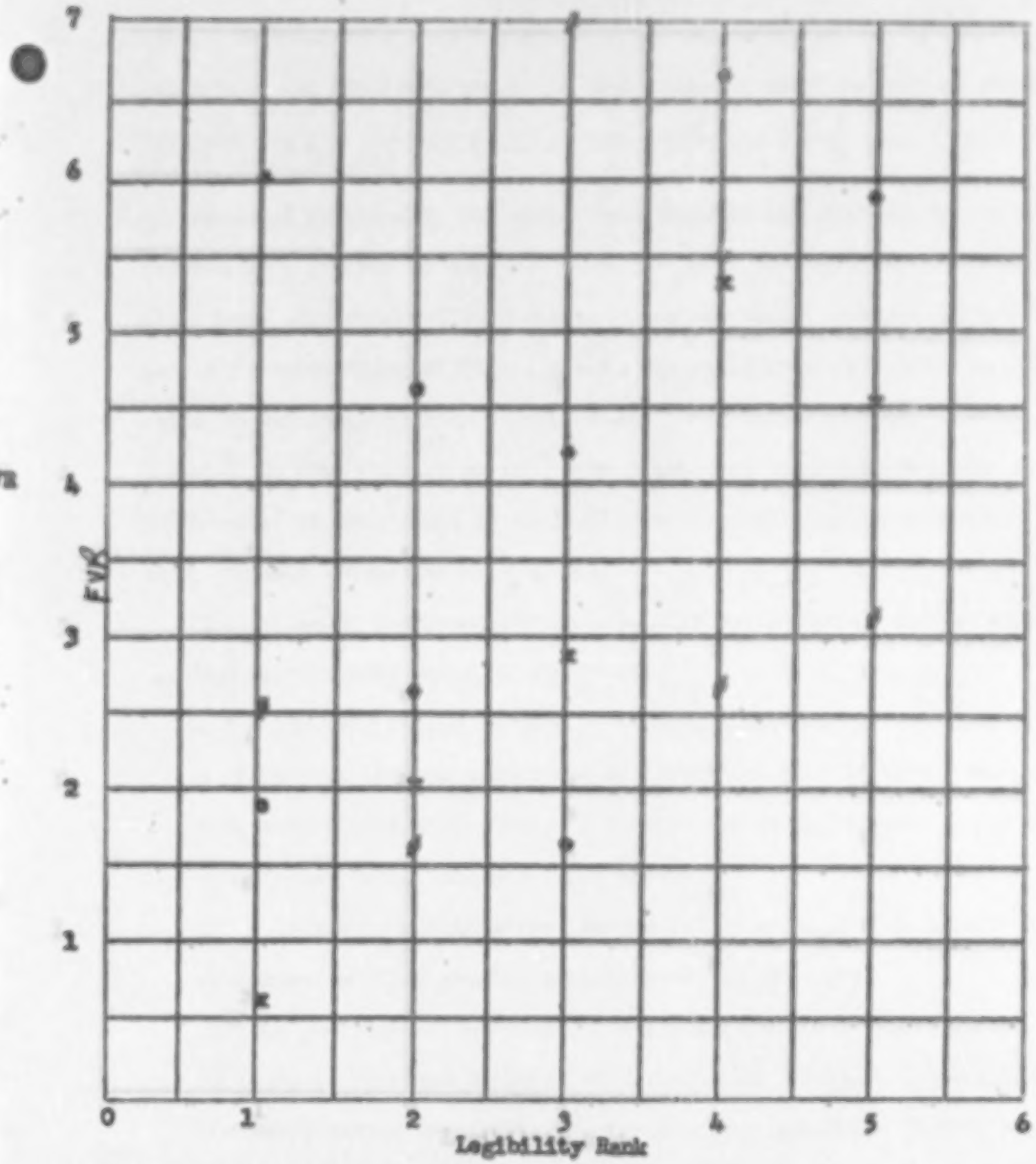
Subjects	Normal Legibility Rank	Normal FVR	Post Legibility Rank	Post FVR	Post Legibility Rank	Post FVR
10IFa	1	1.35	1	1.92	11	1.32
22IFa	2	2.09	2	4.56	2	2.57
23IFa	4	.36	5	3.11	3	1.71
27IFa	3	1.23	3	1.74	4	1.33
30IFa	5	2.89	4	5.53	5	2.84
Mean (Fa)		1.82		3.37		1.95
21IMa	1	1.08	1	.67	1	.56
24IMa	3	1.92	2	2.03	2	1.95
25IMa	4	1.48	3	2.80	3	1.54
28IMa	2	2.45	4	5.39	4	2.86
29IMa	5	4.76	5	4.51	5	2.04
Mean (Ma)		2.33		3.09		1.79
Mean (I)		1.98		3.23		1.87
6IIFa	1	4.64	1	5.99	1	3.49
9IIFa	5	1.70	3	4.22	5	1.71
12IIFa	2	2.10	2	2.64	4	2.55
13IIFa	3	3.13	5	5.76	3	4.56
19IIFa	4	3.16	4	6.55	2	3.41
Mean (Fa)		2.95		5.03		3.14
1IIMa	1	2.16	1	2.50	1	2.23
4IIMa	3	1.52	4	2.65	4	.91
11IIMa	2	1.33	2	1.56	2	1.17
15IIMa	4	1.85	5	3.11	3	2.03
26IIMa	5	4.14	3	6.85	5	2.15
Mean (Ma)		2.20		3.33		1.70
Mean (II)		2.57		4.18		2.62

Figure 3
The Relationship Between Legibility and the Force Variation Ratio
for Normal Samples



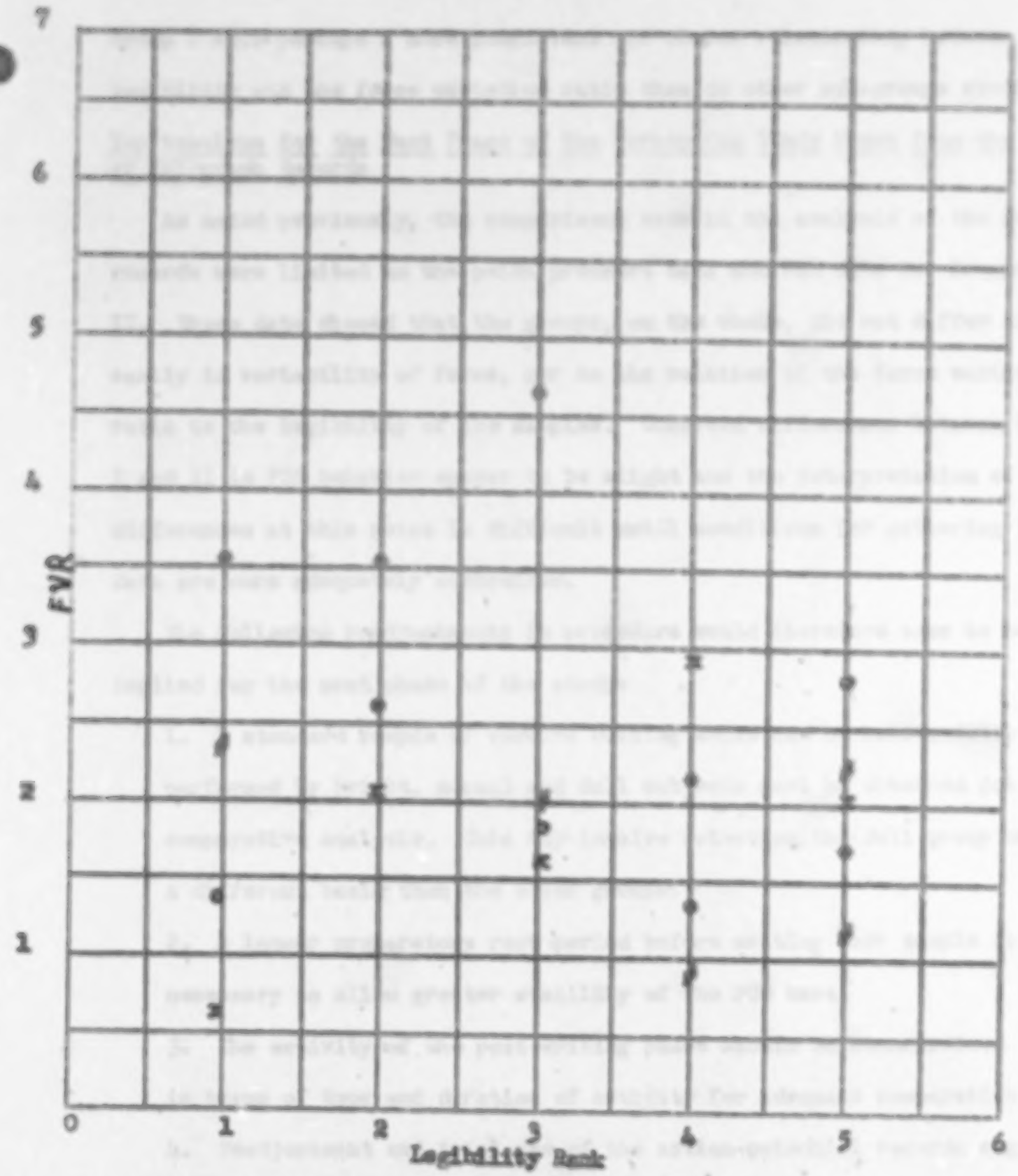
Code: o - IF Group I, Female
x - IM Group I, Male
* - IIF Group II, Female
# - IIM Group II, Male

Figure 4
The Relationship Between Legibility and the Force Variation Ratio
for Fast Samples



Code: o - IF Group I, Female
x - IM Group I, Male
* - IIF Group II, Female
# - IIM Group II, Male

Figure 5
The Relationship Between Legibility and the Force Variation Ratio
for Best Samples



Code: o - IF Group I, Female
x - IM Group I, Male
• - IIF Group II, Female
- IIM Group II, Male

Group I show perhaps a more consistent and closer relationship between legibility and the force variation ratio than do other sub-groups studied.

Implications for the Next Phase of the Perception Study Drawn from the Analysis of Polygraph Records

As noted previously, the comparisons made in the analysis of the polygraph records were limited to the point pressure data and PGR data for Groups I and II. These data showed that the groups, on the whole, did not differ significantly in variability of force, nor in the relation of the force variation ratio to the legibility of the samples. Observed differences between Groups I and II in PGR behavior appear to be slight and the interpretation of such differences at this point is difficult until conditions for gathering the data are more adequately controlled.

The following readjustments in procedure would therefore seem to be implied for the next phase of the study:

1. A standard sample of cursive writing which can be successfully performed by bright, normal and dull subjects must be obtained for comparative analysis. This may involve selecting the dull group on a different basis than the other groups.
2. A longer preparatory rest period before writing each sample is necessary to allow greater stability of the PGR base.
3. The activity of the post-writing phase should be standardized in terms of type and duration of activity for adequate comparative analysis.
4. Readjustment and trial use of the action-potential records suggest that they will prove useful in the succeeding study as a further check upon tension phenomena associated with handwriting.

5. Perception of Value in Handwriting Samples by Three Groups I, II, III.

In the procedure of the over-all perception study, three opportunities were provided for the subjects of the study to indicate levels of aspiration

regarding desired quality of handwriting. The first opportunity for estimating desired quality came before the subject wrote in the experimental setting. Here the standard sentences cut from the standard handwriting scale for fourth grade children were placed before him in random order. The following questions were asked:

Referent

The Handwriting Scale

A. Point out the sample you find easiest to read?

B. Is your own handwriting as easy to read as this?

C. If not, which one of these is about as easy to read as yours?

D. If you would like to make your handwriting more readable (better) which one of these would you wish it to be most like?

As is indicated in these questions, the child is asked (1) to identify his desired model in the scale sentences, (2) to compare his perception of his own handwriting to it, (3) to identify a sample similar to his own, and finally (4) to redefine his desired model. This permits a check on the consistency of his own "aspired-to model," his own appraisal of his level of handwriting as he has internalized it, and finally a comparison of what he sees his handwriting to be with what he would like it to be.

Table 18 on page 46 presents the basic data for this analysis. Column #7 comes from a judgment made by the subject after he has written in the experimental situation and has arranged his normal, fast, and best samples in the order of their perceived quality. He is asked to consider the scaled sentences again as they are presented to him in random order and to pick out a new desired sample. This serves, in effect, as the third check on the consistency of his choice of a desired model of quality. When it is considered that these three choices are made over the thirty minute experimental period separated by dramatic testing experiences, this becomes a severe test of the consistency of the subject's level of aspiration.

Table 18

Consistency of Level of Aspiration Choice by Groups

Subjects Group I	3A	3D	?	(3A - 3D) +	-	0	(3A - ?) +	-	0	(3D - ?) +	-	0
24	1	3	3	-	2	-	-	2	-	-	-	x
16	1	1	1	-	-	x	-	-	x	-	-	x
21	1	1	1	-	-	x	-	-	x	-	-	x
22	1	1	1	-	-	x	-	-	x	-	-	x
23	2	3	3	-	1	-	-	1	-	-	-	-
25	1	1	1	-	-	x	-	-	x	-	-	x
27	1	1	1	-	-	x	-	-	x	-	-	x
28	1	1	1	-	-	x	-	-	x	-	-	x
29	1	1	1	-	-	x	-	-	x	-	-	x
30	2	2	2	-	-	x	-	-	x	-	-	x
	12	15	15			8			8			9
Group II												
4	2	2	2	-	-	x	-	-	x	-	-	x
6	2	-	2	-	-	-	-	-	x	-	-	-
9	2	2	1	-	-	x	1	-	-	1	-	-
11	2	2	2	-	-	x	-	-	x	-	-	x
12	2	-	1	-	-	-	1	-	-	-	-	-
13	3	2	2	1	-	-	1	-	-	-	-	x
15	different form			-	-	-	-	-	-	-	-	-
19	•	•	•	-	-	-	-	-	-	-	-	-
1	•	•	•	-	-	-	-	-	-	-	-	-
26	•	•	•	-	-	-	-	-	-	-	-	-
	9	8	7			3			3			3
Group III												
2	2	1	4	1	-	-	-	2	-	-	3	-
3	6	5	-	1	-	-	-	-	-	-	-	-
5	1	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
10	6	3	-	3	-	-	-	-	-	-	-	-
14	3	-	2	-	-	-	-	-	-	-	-	-
17	1	1	4	-	-	x	-	3	-	-	3	-
18	5	2	5	3	-	-	-	-	x	-	3	-
20	1	4	3	-	3	-	-	2	-	1	-	-
	9	8	10			1			1			0

Consistency of Level of Aspiration Choice by Groups

An examination of the extent to which the three choices of a level of aspiration model deviated from one another indicates that Group I (bright) provided ten complete records and of these 80-90% of them were consistent on all three choices. This is an amazing performance and surprised the investigators. This performance suggests a number of questions. Is mental maturity a factor in developing a clear conception of a desired model of handwriting? How important is this internalized model of quality in determining consistency of level of writing performance? These questions, however, wait for subsequent studies for their answering.

The second group (normal) had only four complete records and of these two or 50% were completely consistent. Part of the difficulty with the second group grew out of the use of the wrong record form in this portion of the study so this phase of the performance of this group is incomplete.

The performance of the third group is most striking. Four complete records were obtained and of these none were consistent on all three choices, one individual consistent on two. It is fairly obvious that it is very difficult for individuals in Group III to make this choice. This suggests the lack of an internalized level of aspiration which serves as a referent for determining quality over more than one instance of handwriting. It could be also that the procedure of the experiment did not provide the same opportunity for individuals in Group III to make this choice.

Judgment of Best Sample

The second opportunity for each subject to reveal his perception of his handwriting comes after he has identified his best sample of writing produced in the experimental situation. Here, he is asked to compare his "best" sample with the scaled sample selected in answer to question 3A. The questions asked at this point are:

1. In comparing your best writing with this sentence are they the same?
2. If the child says no, he is asked if his sample is better? If still no, then he is asked if his sample is worse.

See Table 19 on page 49

Considering Group I, only two of the eight complete records were consistent in answering questions 3B: "Is your handwriting as easy to read as this?" (the selected norm sentence), and question 6,1: "Is your best sample the same as the norm sentence?" Four were inconsistent answering "same" to either questions 3B or 6,1, but not both. Three considered their best sample better than the previously aspired model.

In Group II, of the seven complete records only one was consistent on the two questions. Five were inconsistent and two considered their own writing better than the model.

In Group III, of the eight partial records, two were consistent in their answers to both questions, one inconsistent, and only one considered his writing better than the model.

Again, incompleteness of data makes comparison or analysis difficult. It seems much more difficult for individuals in Group III to make these judgments but if they are made, they seem about as consistent as other groups with individuals of their group not as likely to place their best sample above the previously selected norm sentence.

There seems to be enough valuable possibilities here for future study to justify refinement and improvement of procedures for this section.

Consistency of Judgment of Best and Worst Samples

In question 3C the child is asked to identify a standard sentence which is "about as easy to read as yours." In the final phases of the experimental interview, the child is asked to place his best and poorest samples on a

Table 19

Perceived Similarity of Own Handwriting to Normative Sentence

Subjects	3B	6,1	6,2	6,3
Group I				
24	same	same	-	better
16	same	no	no	-
21	no	same	-	-
22	same	same	-	-
23	same	no	no	better
25	-	-	-	-
27	no	no	yes	-
28	no	same	no	-
29	-	-	-	-
30	same	no	-	no
Group II				
4	same	no	yes	-
6	same	no	-	-
9	same	no	-	better
11	no	same	-	-
12	same	same	-	-
13	-	-	-	-
15	-	-	-	-
19	-	-	-	-
1	no	same	no	better
26	no	no	yes	-
Group III				
2	-	no	no	-
3	no	-	-	-
5	-	no	yes	-
7	-	-	-	-
8	-	-	-	-
10	no	-	-	-
14	same	no	yes	-
17	same	same	-	-
18	same	same	-	-
20	no	no	yes	-

standard scale. These data enable us to compare what the child perceived to be a quality level of his handwriting with two judgments of its actual range. This examination is another test of the "reality" of the child's perception of his handwriting and whether this perception is more closely identified with his "best" rather than his "worst" handwriting.

The following Table 20 on page 51 presents the data for examining the above point.

In Table 20 the judgments made under 3C were compared with evaluations of best (8) and poorest (9) and the positive and negative variations indicated. If the perceived standard sentence is of higher quality than the best sample the variation would be negative. If there is no variation the algebraic sum of these variations would be zero. The table indicates for the bright group that the variation between 3C and 8 is -3 or that these children were choosing a standard sample extraordinarily similar to their best handwriting. The -3 indicates some slight tendency for the standard sample to be better. This finding is supported when 3C is compared with 9 (poorest). The variation -10 is almost identical with the variation which existed between their best and poorest sample. This means that these children saw their previous judgment of their handwriting as being as much different from their poorest as an actual evaluation indicated.

Because of the incompleteness of the data for Groups II and III, similar analyses can not be made for these two groups. These judgments were more difficult for them to make and when they were made, all the variations between the different kinds of comparisons were less.

Summary

Comparisons between the three groups are not possible due to incomplete data but the performance of Group I seems unusually consistent and raises the important question as to how the child's internalized norms of aspiration,

Table 20

Relation of Perception of Handwriting to
Evaluations of Best and Poorest Handwriting

Subjects Group I	3A	7	3C	8	9	3C & 8	3C & 9	8 & 9
24	1	3	1	1	2	0	-1	-1
16	1	1	2	1	1	1	1	0
21	1	1	3	2	5	11	-2	-3
22	1	1	2	1	3	1	-1	-2
23	2	3	-	2	6	-	-	-4
25	1	1	-	-	-	-	-	-
27	1	1	3	4	4	-1	-1	0
28	1	1	1	3	5	-2	-4	-2
29	1	1	-	-	-	-	-	-
30	2	2	1	4	3	-3	-3	1
						-3	-10	-11
Group II								
4	2	2	-	3	4	-	-	-1
6	2	2	-	1	2	-	-	-1
9	2	1	-	4	5	-	-	-1
11	2	2	6	2	2	4	4	0
12	2	1	-	2	2	-	-	0
13	3	2	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-
1	1	1	2	1	3	1	-1	-2
26	1	1	2	2	4	0	-2	-2
						5	1	-7
Group III								
2	2	4	6	-	-	-	-	-
3	6	-	1	-	-	-	-	-
5	1	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-
10	6	-	-	-	-	-	-	-
14	3	2	2	1	3	1	-1	-2
17	1	4	4	5	2	-1	2	3
18	5	5	1	-	-	-	-	-
20	1	3	-	-	-	-	-	-
						0	1	1

normative perception of own handwriting, and referents for differentiating the quality of his handwriting are developed. The bright group seemed to have these qualities in a high degree. All of these qualities seem to be important in adequate skill training and deserve further study.

6. Placement of Best and Poorest Sample on Scales

The final judgment made by the subjects of this study had to do with taking the sample of their own writing which they had previously judged to be "best" and to place it at the appropriate level on a standard scale of handwriting samples of fourth grade children. This task was followed by each individual using his "poorest" sample and following the same procedure.

The major ideas behind this phase of the study had to do with the following questions:

1. Can these children place their best and poorest samples accurately on the handwriting scale? Will their own valuing of their handwriting products cause them to distort their evaluation?

2. If there is bias in the sample placement, will the "best" sample be the one most affected. Will it be the "poor" sample and will the bias be in the negative direction (undervaluate).

3. What is the range of difference existing between the "best" and "poorest" samples of these children?

It is not proposed that this exploratory study will give final answers to these questions but merely that some preliminary judgments can be made.

The basic choice data for this portion of the study is found in Table 21 on page 53.

Relationships Between Judgments of Children with Judges

The product-moment correlations for the total group with the ratings of the same samples by the judges are as follows:

Table 21

Judgments of Poorest and Best Samples

Subjects	Child *8	Child **9	Judge I 8	Judge I 9	Judge II 8	Judge II 9
	1	2	3	4	5	6
1	3	2	4	3	1	4
2						
3						
4	3	4	3	5	4	5
5						
6	1	2	1	2	2	4
7						
8						
9	4	5	4	4	4	5
10						
11	2	2	4	5	3	4
12	2	2	3	3	3	4
13	1	3	3	4	3	4
14						
15	1	6	3	5	2	5
16	1	1	1	1	3	4
17						
18						
19	2	4	3	4	2	5
20						
21	1	2	1	1	3	4
22						
23	2	6	4	6	4	6
24	1	2	2	3	2	4
25	1	3	2	4	4	5
26	3	3	6	6	6	6
27	2	4	4	5	4	4
28	4	4	5	6	4	6
29	3	5	6	6	3	6
30	4	3	3	4	3	4
Sum	41	63	61	77	60	89
Ave	2.16	3.32	3.21	4.05	3.16	4.68
σ	1.08	1.41	1.47	1.55	1.08	.82

*Best

**Poorest

1 = Child's rating of best
2 = Child's rating of poorest
3 = 1st Judge's rating of best
4 = 1st Judge's rating of poorest
5 = 2nd Judge's rating of best
6 = 2nd Judge's rating of poorest

$r_{13} = .672$
$r_{15} = .325$
$r_{24} = .709$
$r_{26} = .675$

The highest correlation is the child's ratings with the ratings of the first judge. In this respect the "best" and "poorest" have equally high correlations suggesting that the ratings on the basis of their criterion were about equally accurate. Considering the second judge, the greatest discrepancy existed in the ratings of the "best" samples by this judge. The correlation with the "poorest" sample is approximately the same as the correlation with the first judge.

These results mean, that if we can accept the judge's ratings as our referent, that the children rated their samples about in the same way as did adult judges. Apparently, there was little difference in the accuracy of the placement of best and poor samples.

Consistency of Judges

Further examination was made of the consistency of the two judge's ratings when compared with each other's ratings. The correlations here are $r_{35} = .47$ (best with best), $r_{46} = .74$ (poorest with poorest). These data further support the above generalization that the second judge's rating of the "best" samples is different than either the children's or those of the first judge.

Relationship Among Best and Poorest Ratings

It is necessary to ask the last question regarding these ratings. Did the judgments differentiate between the best and poorest ratings. The correlations are:

$r_{12} = .303$ (child's best with poorest)
$r_{34} = .852$ (1st judge's best with poorest)
$r_{56} = .530$ (2nd judge's best with poorest)

Here, if there was a difference between the best and poorest samples and if these differences were properly recognized by the judges, then we would expect these correlations to move in the direction of a negative one. If, however, the opposite would be true, the correlations would move in the direction of a positive one. With this in mind, apparently the children and the second judge differentiated most between best and poorest samples in their ratings. The first judge apparently evaluated the best and poorest samples on the scale in a very similar fashion.

Testing the Significance of Differences

The t test for the significance of the difference would further evaluate the above findings. We check to examine the extent to which the children differentiated their evaluations for the best and poorest samples revealed the following results:

	Level of Significance
$t_{12} = 2.8501$	.01
$t_{34} = 1.5132$	.15
$t_{56} = 4.8717$	beyond .01

This verifies the previous finding that the children and the second judge did differentiate between the best and the poorest in their ratings and that the first judge did not.

The significance of the other comparisons are indicated by the following t tests:

	Level of Significance
$t_{13} = 2.5059$	.02*
$t_{15} = 2.8571$	.01*
$t_{24} = 1.5240$	.15
$t_{26} = 3.6363$	beyond .01*
$t_{35} = .1193$	.90
$t_{46} = 1.5671$	.15

* Meet criterion

The comparison of the child's ratings of their best sample with those of the two judges reveal significant differences. The ratings of the children of their poorest sample reveals similarity with the first judge and significant difference with the second (beyond .01). Considering the judges, there is great agreement among their judgments of the best samples and less agreement regarding the poorest.

These data while tending to support the correlations bring the differences among the evaluation into sharper relief. These data have the following implications for future studies.

1. The actual difference between a child's poorest and "best" handwriting under the conditions of the study may be very slight.

2. Additional trained judges should be used to stabilize norms used for referent.

3. The findings look promising for examining the valuing operations of children.

4. Care must be exerted in obtaining comparable samples from all three groups of children. (No comparison of groups was possible due to the dull groups' writing only in manuscript and then only incompletely; they were eliminated from the above analysis.)

Section II

Conclusions and Implications of the Study

The major conclusions of this preparatory study of the perception of symbols in skill learning by mentally retarded, gifted, and normal children will be summarized first. The implications of these findings for the analysis of data, for instrumentation, and for experimental procedures will then be presented.

7. Summary of Major Findings Drawn from the Analysis of Data

1. All children passed the visual screening tests satisfactorily.

2. The screening tests for fine motor coordination show that:

a. There is a high and significant degree of consistency between trials I and II for the total group of subjects.

b. There were significantly higher motor coordination scores for Group I (bright) than for Group III (mentally-retarded)

3. The data on time taken to reproduce the stimulus, "The fox jumped," in the subjects' Normal, Fast, and Best handwriting, indicate that:

a. A high degree of consistency exists between the average time for three trials and that of the Normal sample.

b. A Fast sample was produced in each case well within the "ten per cent faster than normal" criterion.

c. There is close similarity in time between Normal and Best samples.

d. There are significant differences in time between samples only in making comparisons with Fast samples, not in comparisons of Normal with Best samples in any group.

e. No significant differences appear in between-group comparisons of time in writing.

4. Sample against sample ratings of legibility show that:

a. Subject and two judges were able to make significant discriminations between the Best, Normal, and Fast samples of an individual in that order, (Best being judged best, and Fast, the poorest).

b. Some variability was found to exist in the three sets of ratings (subject, judge I, judge II) for a given type of sample, but in general the two judges agreed more closely than did subjects and judges.

5. Analysis of the polygraph records, involving data for pen point pressure and the psycho-galvanic reflex (PGR) for Groups I and II only, show that:

   a. The force variation ratio analysis failed in general to reveal any differences significant at the 5% level between groups or sexes although some significant differences exist in the comparisons of Fast-Best and Fast-Normal samples.

   b. The PGR activity in terms of number and magnitude of "peaks" tends to reach a well defined peak in the great majority of cases within two seconds of the beginning of the writing phase, and within the three-second post-writing phase.

   c. There is little apparent relationship between legibility rankings, on a sample against sample basis by sex within groups, and the force variation ratio.

6. Data for consistency of level of aspiration choice indicate that:

   a. The bright group shows a high degree of consistency in three choices of a level of aspiration model, a performance which was not matched by the complete records of normal and dull subjects.

   b. Comparisons of subjects' Best sample with the aspired-to scale sample appears to be a difficult task for all groups.

   c. The bright group shows marked ability to place their best and poorest samples on a scale in relation to a sample previously identified as "about as easy to read as yours."

7. In accuracy of placement of best and poorest samples in a standard scale, the data show that:

   a. Pupils and two adult judges tend to rate samples in about the same way on the scale.

   b. Some variability exists in the consistency between the two judges' ratings and in the nature of their differentiation between best

and poorest samples.

8. Implications of the Study

Implications drawn from the analysis of the data:

1. Satisfactory visual screening of subjects can be easily accomplished.
2. Differences in fine motor coordination between bright and mentally-retarded children in particular should be studied further, especially in relation to their ability to pr duce legible handwriting.
3. All groups apparently can be expected to easily produce within satisfactory time limits a stable Normal sample and a differentiated Fast sample. The close relationship in time for the normal and best samples may be due to the fact that the Best sample is produced immediately following the Fast sample. The subject may, therefore, be comparing the time taken to produce the Best sample relatively with the time used in producing the Fast sample. Thus, if we introduce another Normal sample after the writing of the Fast followed then by the Best, a greater differentiation in times for the Normal-Best samples may be obtained.
4. While subjects may be expected to discriminate among their writing samples according to legibility, the relative ability of the three groups to discriminate should be explored further.
5. It may be desirable to explore the use of a ratio between PGR peak location and amplitude in connection with the onset of writing for a more explicit understanding of the relationships involved.
6. Because of individual variations in skin resistance and other factors it would seem that primary attention in the analysis of PGR data should be given to data for the individual and that less emphasis should be placed upon inter-personal and inter-group comparisons.
7. Bright children in Group I appear to possess extraordinary perceptual discrimination and consistency in its application in making judgments relative to their level of aspiration.

8. Actual differences between the poorest and best handwriting of a child may be very slight.

Implications of the Study for Experimental Procedures

1. It may be desirable to have subjects write a second Normal sample after writing their Fast sample so that the immediate referent for the Best sample, written last, will also be a Normal sample. If the order of samples were arranged thus--(1) first Normal, (2) Fast, (3) second Normal, and (4) Best--it might be hypothesized the most time would be taken as a rule to produce the Best sample.

2. Judges used for rating handwriting samples should be carefully trained. This training should emphasize:

   a. Clarification of the referent for differentiating samples.

   b. Use of a trial run of judging with evaluation of results with a member of the research staff.

3. Greater control over the subjects' behavior for a longer period before and after writing in the experimental booth is necessary to secure adequate evidence of tension phenomena by means of PGR and muscle action-potential records. Specifically:

   a. The time when instructions to subject are begun should be indicated on the record.

   b. The behavior following the writing should be normalized.

4. A common cursive sample which can be successfully performed by all three groups is essential for comparative analysis of the polygraph records. This may necessitate selecting the mentally retarded group on a different basis.

5. Improved procedures for scaling sample and for gathering comparable level of aspiration data for each group need to be devised. There is need for:

a. More precisely defined scale intervals which would discriminate between examples of the same person's handwriting.

b. Scales should maintain levels of legibility but should vary slant, size, density of line, roundness of letter

Implications of the Study for Instrumentation

1. The motor coordination target needs to be re-designed (1) to record errors as well as hits, and (2) to avoid errors in counting extra "hits". occasionally caused by "sparking" between the target and the stylus. It is also possible that concealing the electric counter and dampening its sound may reduce cues which apparently cause some children to poke again at a missed target.

2. Technical adjustment of the muscle action-potential circuit has been completed so that valid action-potential records may be secured in the next phase of the study.

9. Concluding Statement.

This exploratory study has provided the basis for the development of many important changes and improvements in the testing procedures, instrumentation, and in sample definition. There is also data here for the needed identification and sharpening of the independent-dependent variables important in the future study of perception in skill areas. Most important, is the greater confidence we have gained in our ability to get at the normative perceptions children have of their handwriting and to examine the influence of this perception on the skill behavior of children of different levels of ability.